Measurement of the properties of Higgs boson production at $\sqrt{s}$ = 13 TeV in the H→γγ channel using 139 fb^{-1} of pp collision data with the ATLAS experiment

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DPF Meeting
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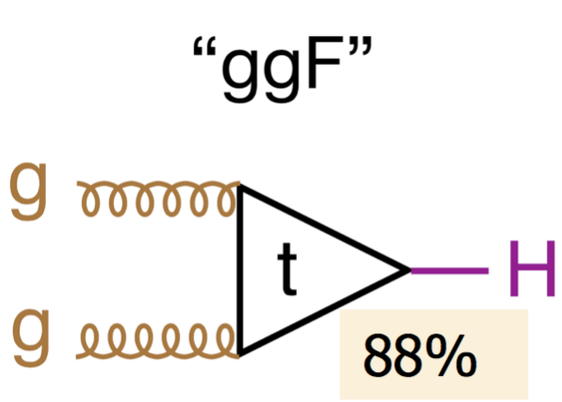
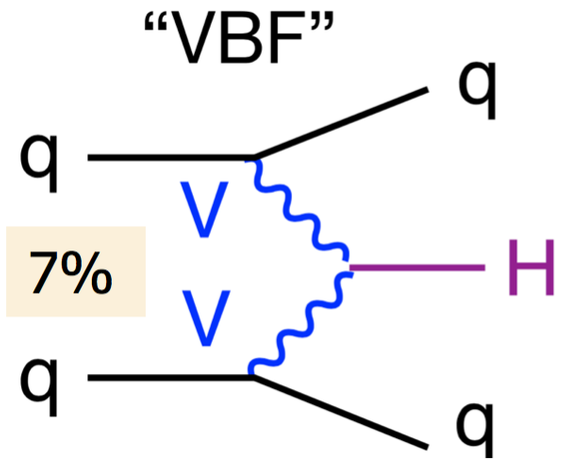
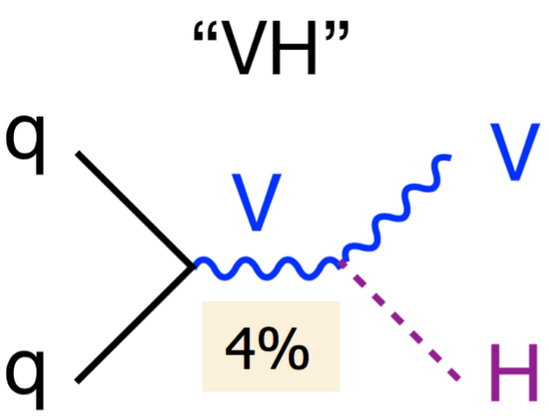
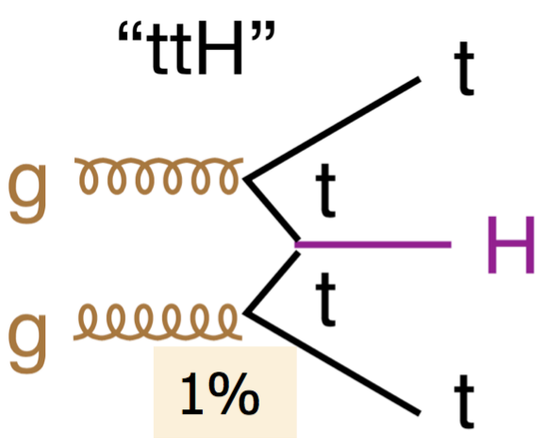
Higgs boson production and decay modes

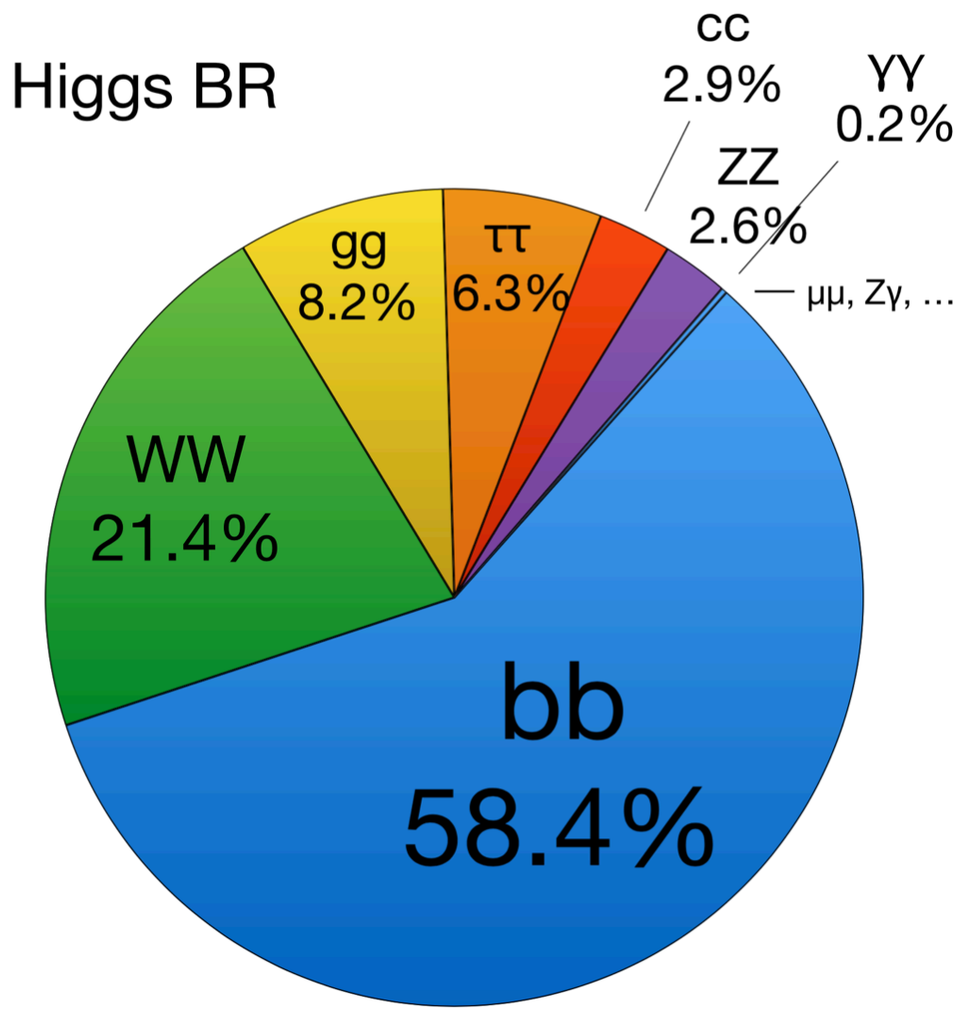
- In the Standard Model, the Higgs boson couples to massive bosons and fermions
- These couplings determine the Higgs boson production and decay modes:









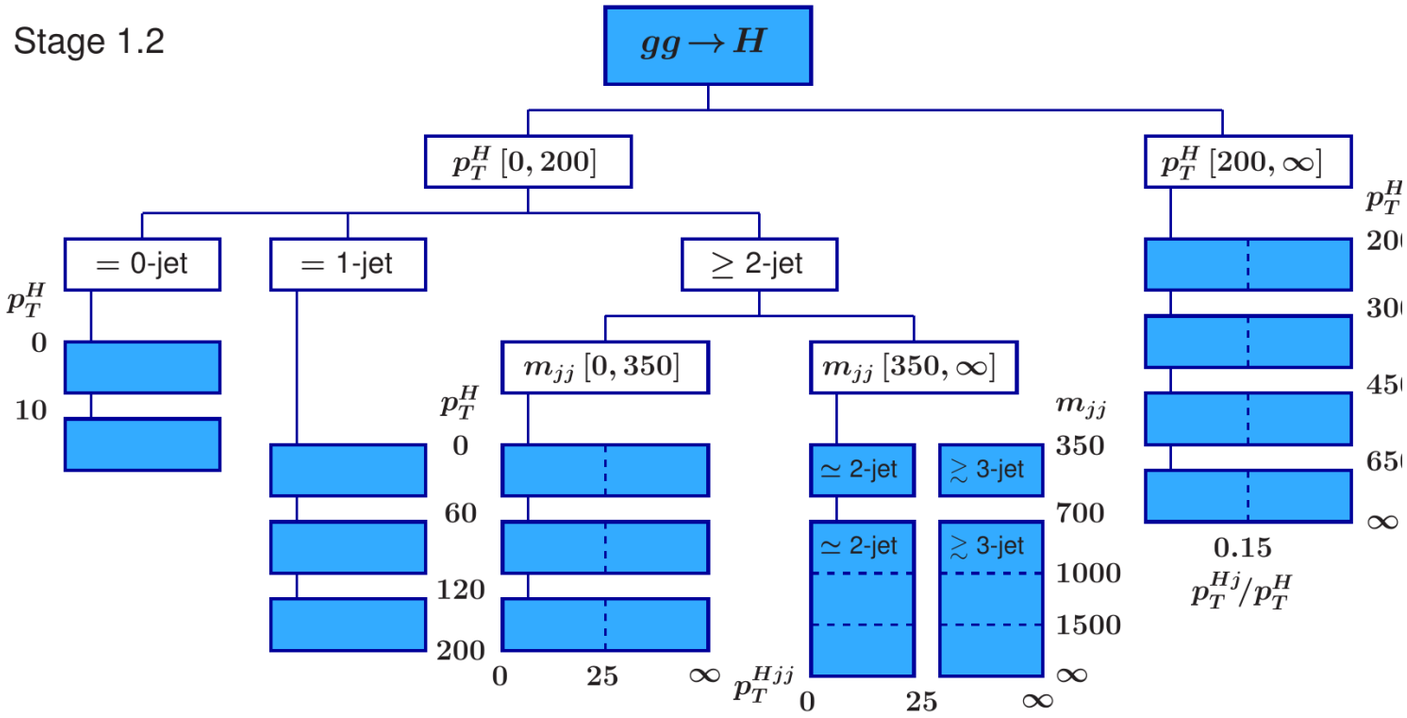


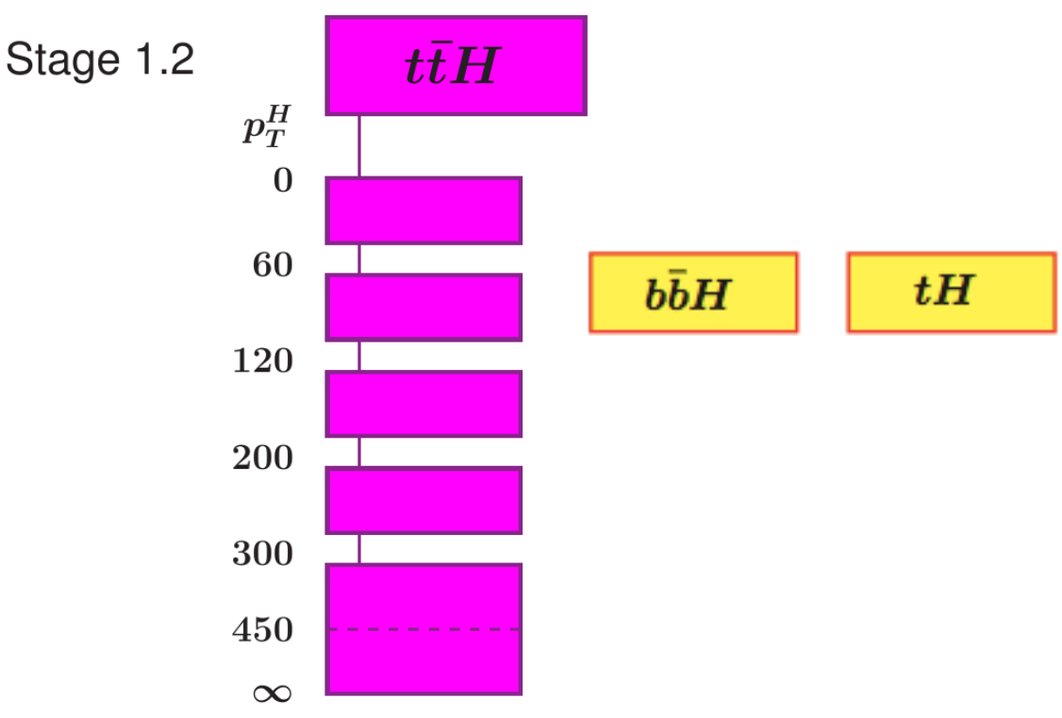
Figures from https://msneubauer.github.io

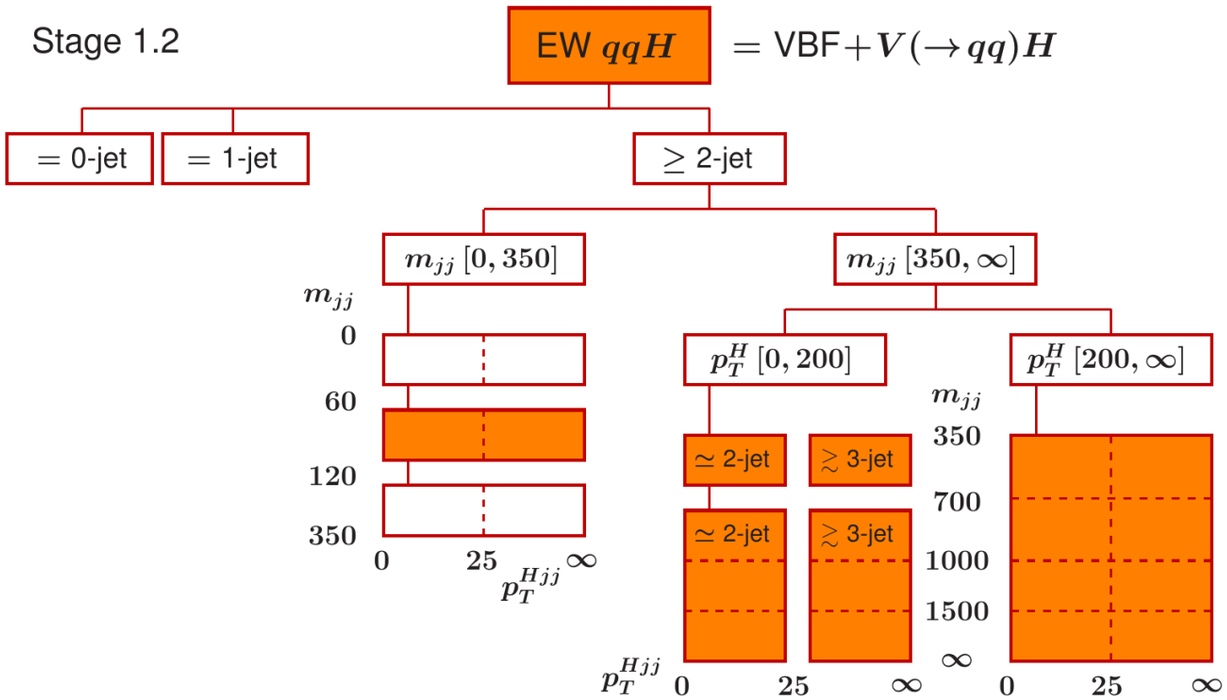
Higgs coupling property measurements

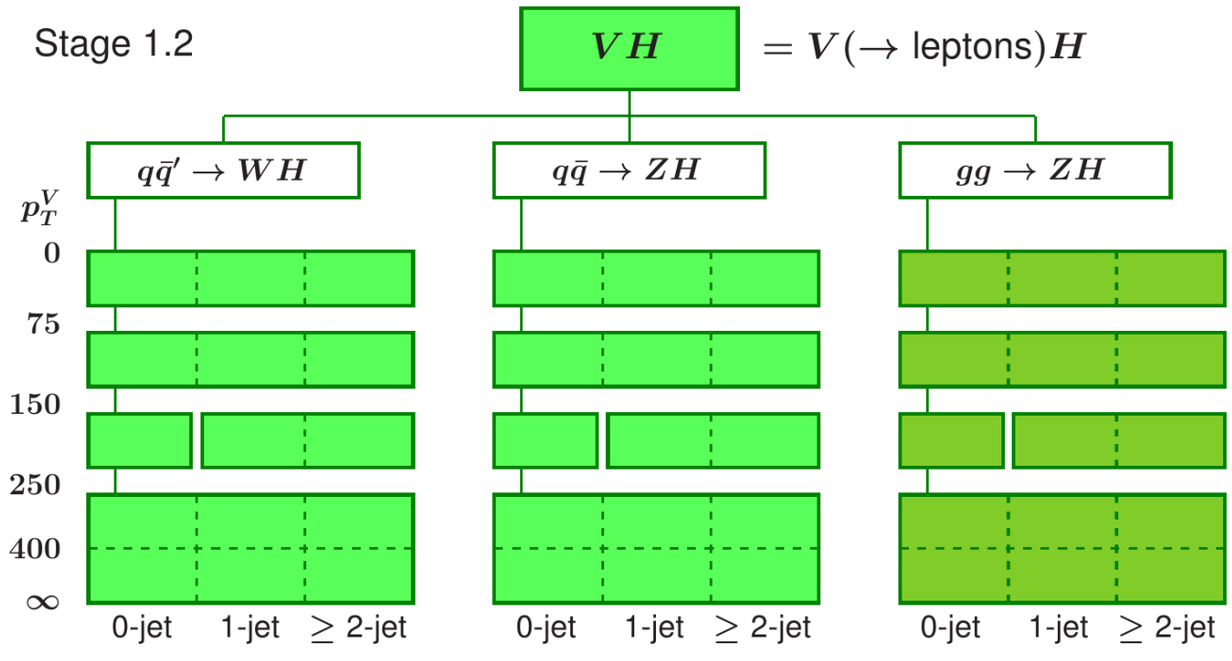
- ATLAS performed measurements of Higgs boson coupling properties:
  - provide stringent test of the Standard Model
- Simplified template cross section (STXS) is the common framework for the LHC Higgs coupling property measurements in Run 2
  - split production mode cross-sections into various phase-space regions, which are chosen according to sensitivity to beyond Standard Model effects, avoidance of large theory uncertainties, matching to experimental selections
- This talk discusses the measurements in the $H \to \gamma\gamma$ channel (139 fb^{-1}, 13 TeV)

Stage 1.2 STXS









H→γγ analysis strategy

Select events with **two photons** (at both trigger and offline levels)

➔Separate events to **many categories**

- target different STXS regions

➔Fit **diphoton mass** over all categories

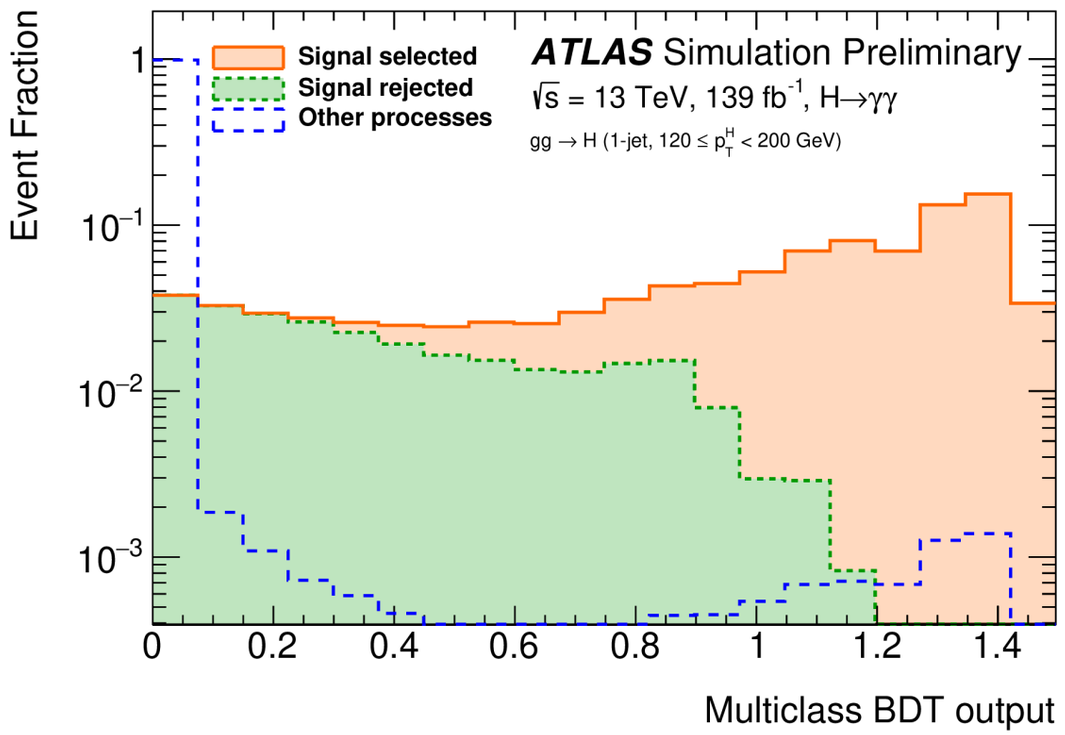
- Signature: a narrow resonance with a width consistent with detector resolution above a smooth background in the diphoton invariant mass distribution

➔Measure production mode cross sections, simplified template cross sections, etc.

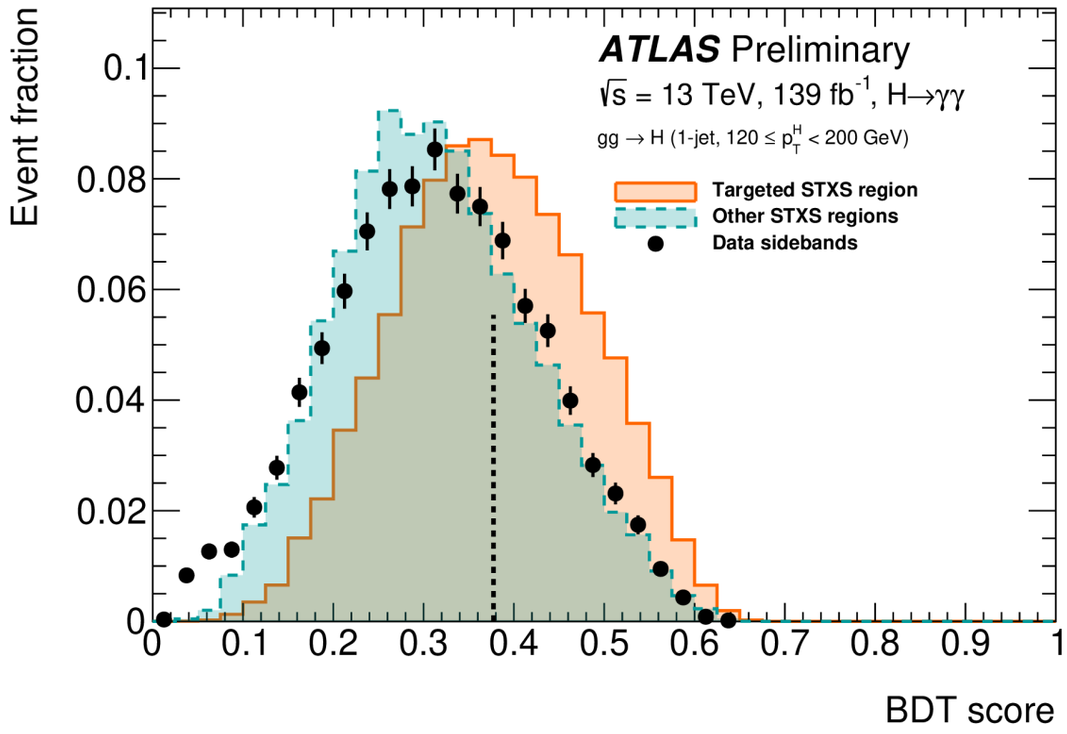
Event categorization

Designed to maximize the global sensitivity to all STXS regions

- Step 1: A multi-class boosted decision tree (BDT) is trained to separate signal events from different STXS regions.
  - Then, the output discriminant values are used to assign events into different classes.



- Step 2: Each class of events is further divided into multiple *categories* based on a binary BDT classifier.
  - This binary BDT is trained to separate signal from continuum background in each class.



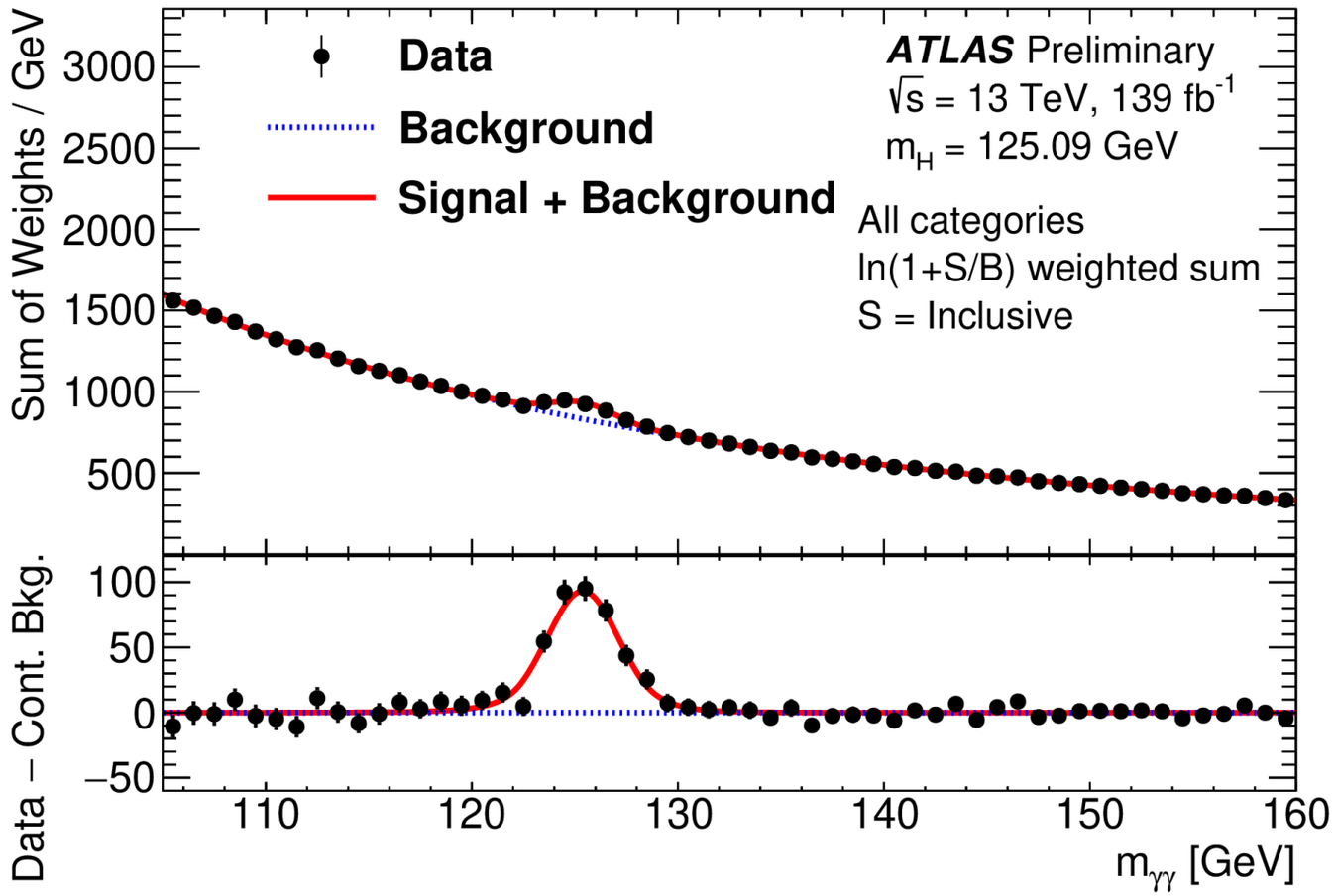
Finally, 88 event categories in total

- S/(S+B) ranges from 3% to 83%

Signal and background modeling

- **For each event category, need to model diphoton mass distributions of signal and backgrounds**
- **Model of Higgs signal**
  - Expected yields of Higgs production modes: estimated from simulation
  - Mass shapes: parametrized from simulation with double-sided crystal ball functions
- **Model of continuum background**:
  - Analytical functions fitted on data
  - Using dedicated background-only samples
    - studied functional forms and associated uncertainties

Diphoton mass: all categories



ATLAS-CONF-2020-026

- Diphoton mass spectrum peaks at the Higgs mass around 125 GeV
- ~6,900 H→γγ events fitted over 88 categories (~1.2 million data events are selected)

Total cross section

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The Higgs boson production cross section times $H \to \gamma\gamma$ branching ratio is measured to be

$$(\sigma \times B_{\gamma\gamma})_{\text{obs}} = 127 \pm 10\,\text{fb} = 127 \pm 7\,(\text{stat.}) \pm 7\,(\text{syst.})\,\text{fb}$$

with an SM expectation of

$$(\sigma \times B_{\gamma\gamma})_{\text{exp}} = 116 \pm 5\,\text{fb}.$$

- Similar impacts from the statistical and systematic uncertainties
- The cross sections in this talk are defined in the Higgs boson rapidity range $|y_H| < 2.5$

Production mode cross sections

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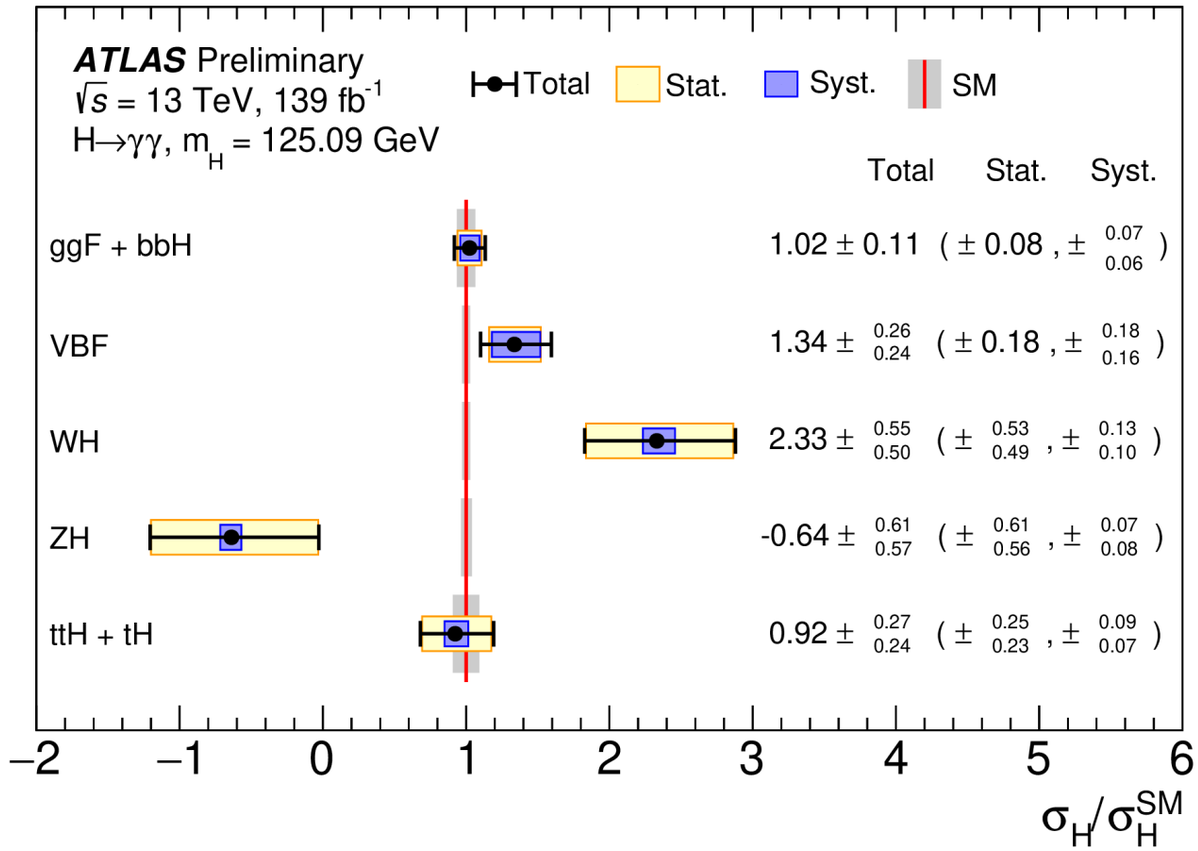

- ggF cross section is measured with 11% precision
  - Precision of N3LO cross section prediction: 5%
- The observed (expected) significance:
  - VBF: 7.5σ (6.1σ), WH: 5.6σ (2.8σ), ZH: 0σ (1.7σ), $t\bar{t}H$+tH: 4.7σ (5.0σ)
- An upper limit of 8 times the Standard Model prediction is set for tH production
  - the most stringent experimental constraint on tH

Production mode cross sections

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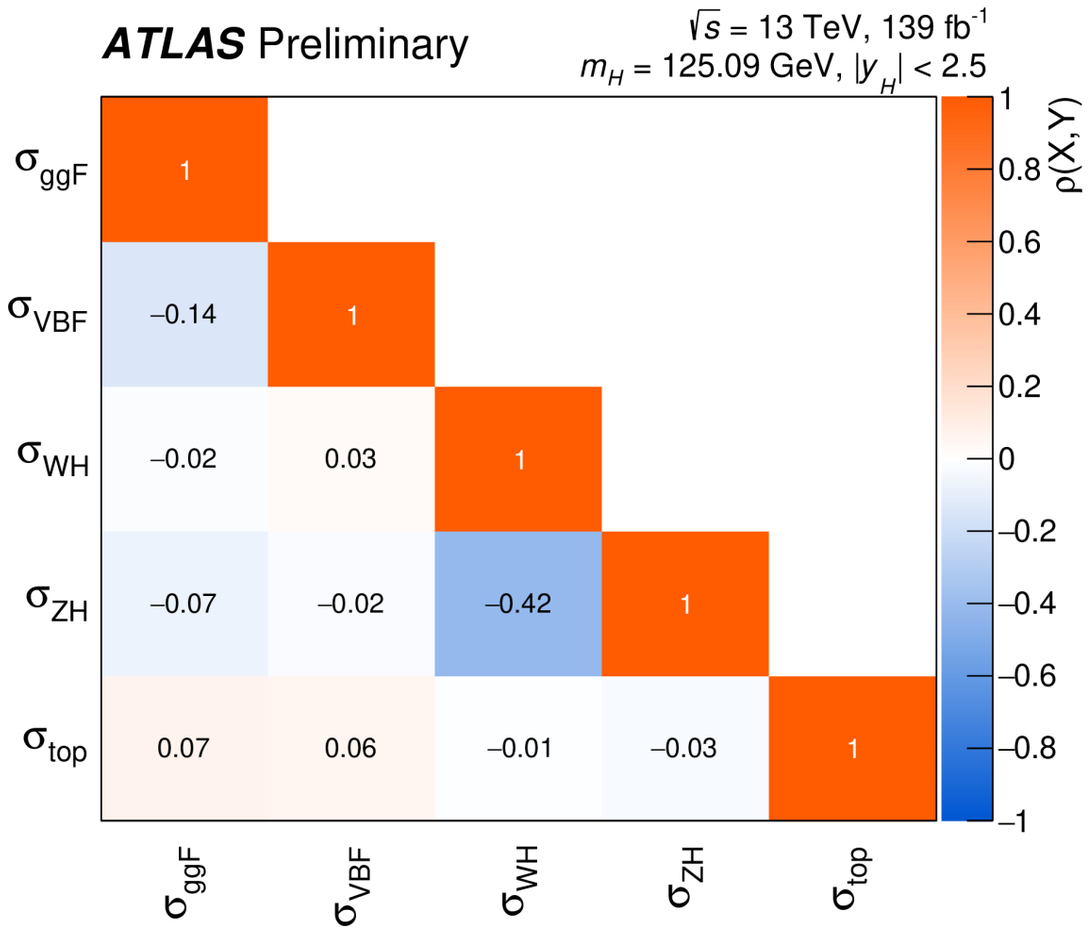

- Correlation between ggF and VBF is now 14% (which was 27% in a previous result)
- Correlation between WH and ZH is relatively large (42%)
- The compatibility with SM prediction corresponds to a p-value of 3%
  - Difference is mainly due to the larger than expected yield for WH, and smaller than expected yield for ZH

Impact of systematic uncertainties

- underlying event & parton showering modeling uncertainty, continuum background modeling uncertainty, and jet-related uncertainties are the highest ranked systematics

	ggF+ $b\bar{b}H$	VBF	WH	ZH	$t\bar{t}H$+ tH
Uncertainty source	$\Delta\sigma$[%]	$\Delta\sigma$[%]	$\Delta\sigma$[%]	$\Delta\sigma$[%]	$\Delta\sigma$[%]
Underlying Event and Parton Shower (UEPS)	± 2.3	± 10	$< \pm 1$	± 9.6	± 3.5
Modeling of Heavy Flavor Jets in non-$t\bar{t}H$ Processes	$< \pm 1$	$< \pm 1$	$< \pm 1$	$< \pm 1$	± 1.3
Higher-Order QCD Terms (QCD)	± 1.6	$< \pm 1$	$< \pm 1$	± 1.9	$< \pm 1$
Parton Distribution Function and α_S Scale (PDF+α_S)	$< \pm 1$	± 1.1	$< \pm 1$	± 1.9	$< \pm 1$
Photon Energy Resolution (PER)	± 2.9	± 2.4	± 2.0	± 1.3	± 4.9
Photon Energy Scale (PES)	$< \pm 1$	$< \pm 1$	$< \pm 1$	± 3.4	± 2.2
Jet/$E_{\mathrm{T}}^{\mathrm{miss}}$	± 1.6	± 5.5	± 1.2	± 4.0	± 3.0
Photon Efficiency	± 2.5	± 2.3	± 2.4	± 1.4	± 2.4
Background Modeling	± 4.1	± 4.7	± 2.8	± 18	± 2.4
Flavor Tagging	$< \pm 1$	$< \pm 1$	$< \pm 1$	$< \pm 1$	$< \pm 1$
Leptons	$< \pm 1$	$< \pm 1$	$< \pm 1$	$< \pm 1$	$< \pm 1$
Pileup	± 1.8	± 2.7	± 2.1	± 3.8	± 1.1
Luminosity and Trigger	± 2.1	± 2.1	± 2.3	± 1.1	± 2.3
Higgs Boson Mass	$< \pm 1$	$< \pm 1$	$< \pm 1$	± 3.7	± 1.9

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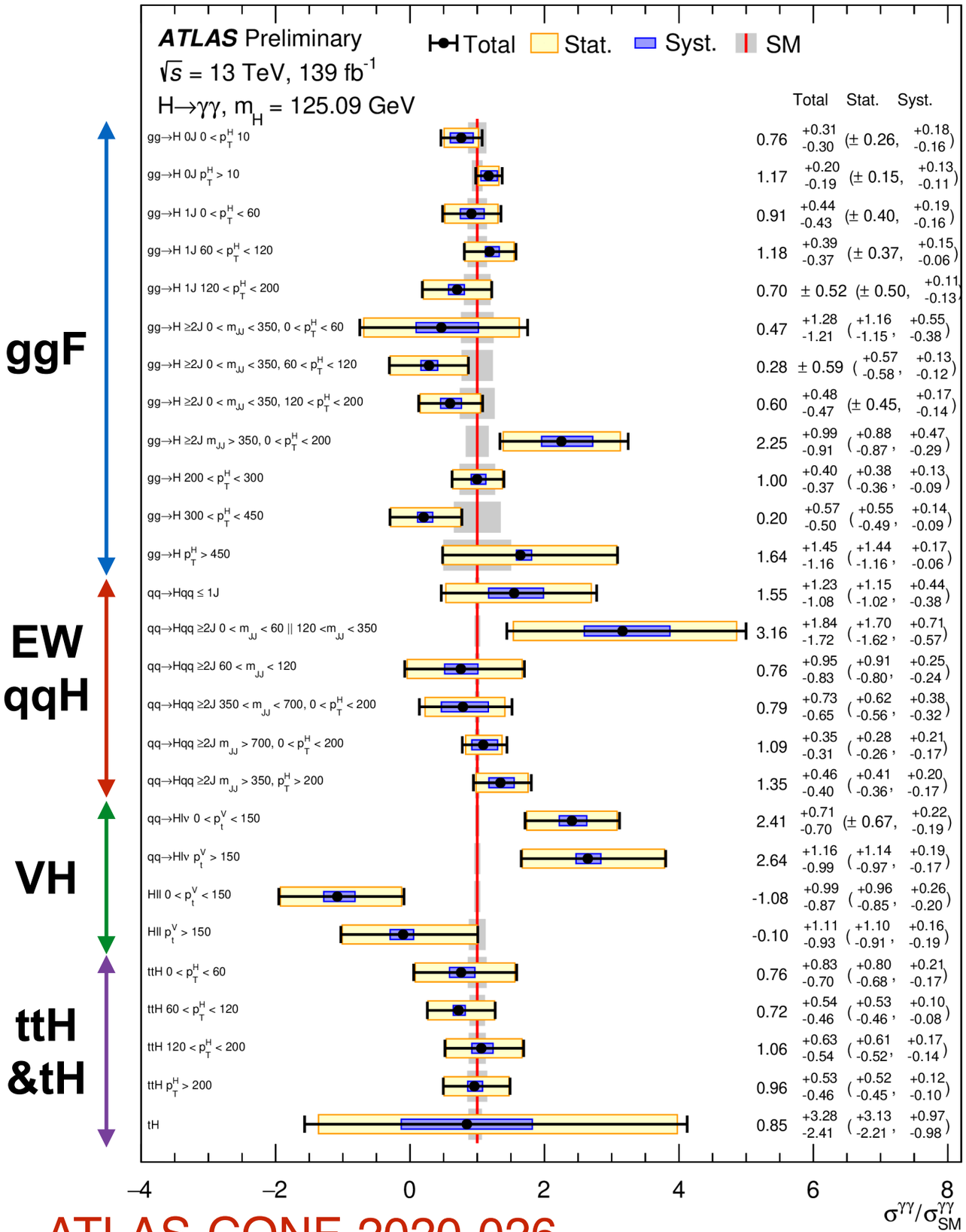
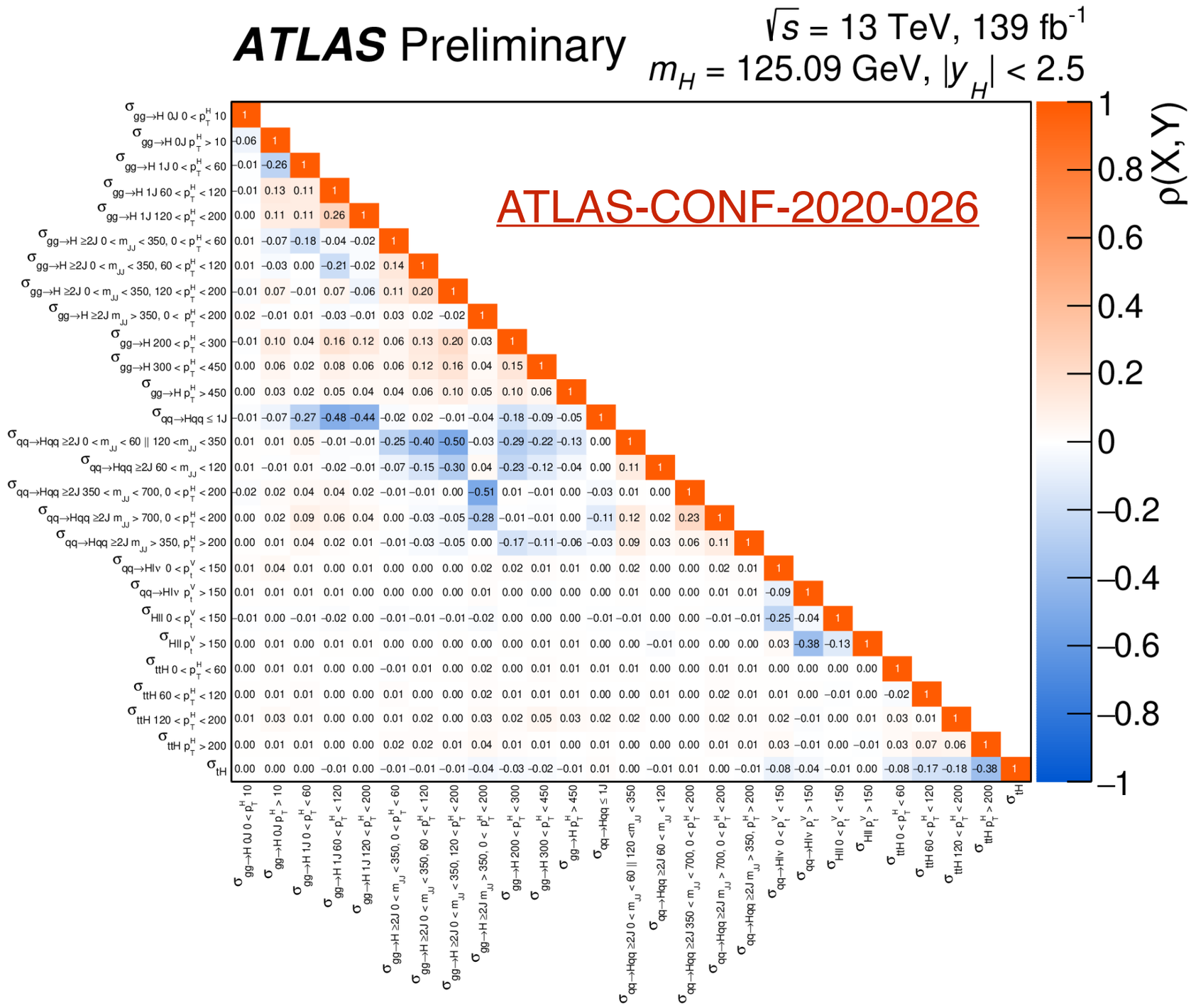
Simplified template cross sections



ATLAS-CONF-2020-026

- We measure Higgs production granularly
  - 27 merged STXS regions are measured
  - Uncertainties range from 20% to more than 100%, mostly statistically dominated
- We measure $t\bar{t}H$ production differentially in Higgs pT (two years after its observation)
  - sensitive to self-couplings of the Higgs
- Good compatibility with the SM (p-value of 60%)

Simplified template cross sections



- The largest correlations are mainly between certain ggH and EW qqH regions that have similar kinematics

Summary

- Based on **139 fb^{-1}** of full Run 2 data, ATLAS performed measurements of Higgs boson production in the H→γγ channel (ATLAS-CONF-2020-026):
  - total cross section
  - production cross sections
  - simplified template cross sections

- H→γγ is one of the most sensitive channels for ggF, VBF, $t\bar{t}H$ and tH
- All measurements are in agreement with the SM within the improved precisions
- Results can be used to probe Higgs self-couplings and BSM effects
- Please stay tune for the journal publication of our measurements

Backup slides

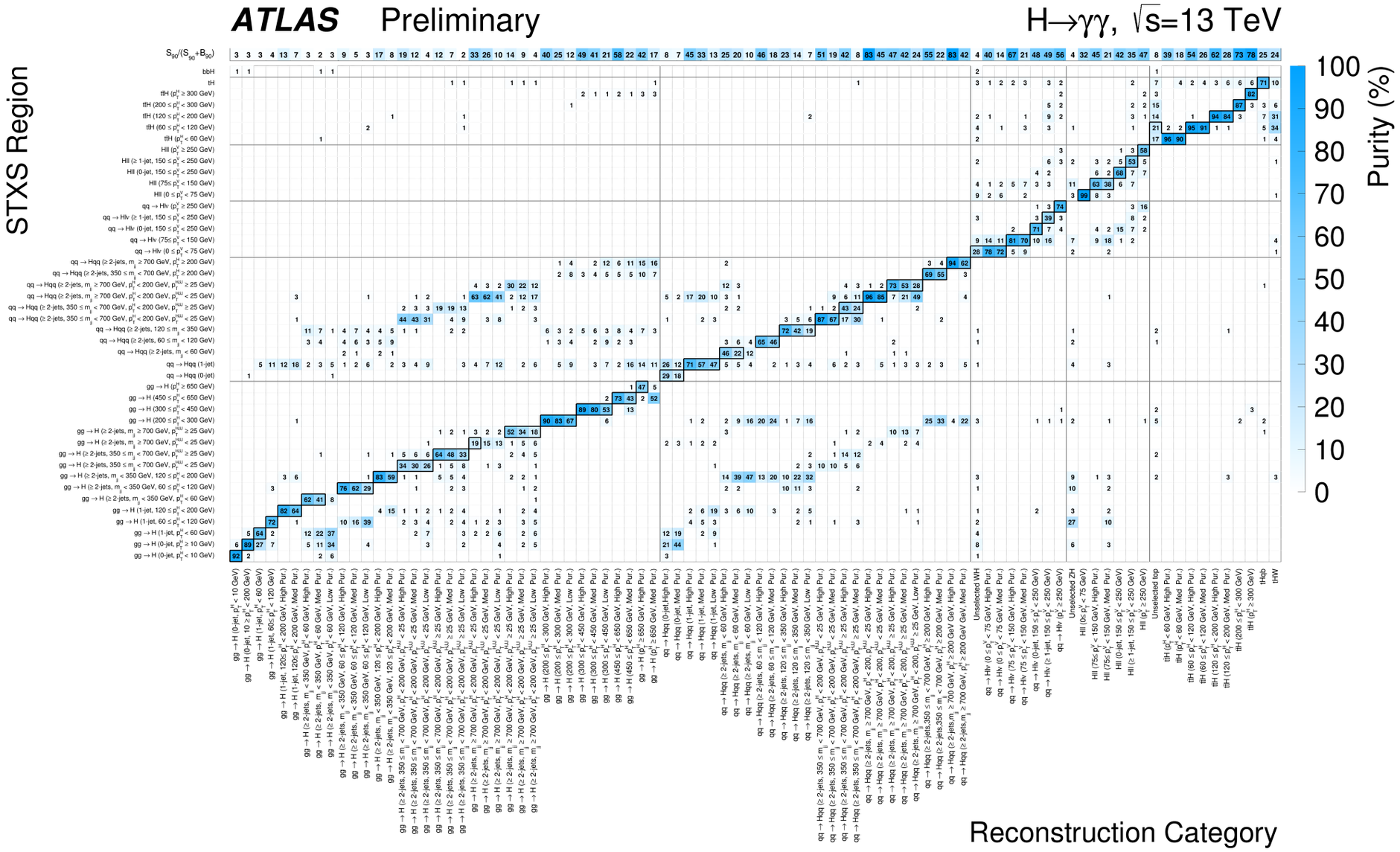
Monte Carlo samples

Process	Generator	Showering	PDF set	σ [pb] $\sqrt{s} = 13$ TeV	Order of σ calculation
ggF	NNLOPS	Pythia 8	PDF4LHC15	48.52	N^{3}LO(QCD)+NLO(EW)
VBF	Powheg-Box	Pythia 8	PDF4LHC15	3.78	approximate-NNLO(QCD)+NLO(EW)
WH	Powheg-Box	Pythia 8	PDF4LHC15	1.37	NNLO(QCD)+NLO(EW)
$qq/qg \to ZH$	Powheg-Box	Pythia 8	PDF4LHC15	0.76	NNLO(QCD)+NLO(EW)
$gg \to ZH$	Powheg-Box	Pythia 8	PDF4LHC15	0.12	NLO(QCD)
$t\bar{t}H$	Powheg-Box	Pythia 8	PDF4LHC15	0.51	NLO(QCD)+NLO(EW)
$b\bar{b}H$	Powheg-Box	Pythia 8	PDF4LHC15	0.49	NNLO(QCD)
$tHqb$	MG5_aMC@NLO	Pythia 8	NNPDF3.0nnlo	0.07	NLO(QCD)
tWH	MG5_aMC@NLO	Pythia 8	NNPDF3.0nnlo	0.02	NLO(QCD)
$\gamma\gamma$	Sherpa	Sherpa	NNPDF3.0nnlo		
$V\gamma\gamma$	Sherpa	Sherpa	NNPDF3.0nnlo		
$t\bar{t}\gamma\gamma$	MG5_aMC@NLO	Pythia 8	NNPDF2.3lo		

BDT Training variables

<table>
<tr><th>STXS regions</th><th>Multi-class BDT</th><th>STXS regions</th><th>Binary BDT</th></tr>
<tr><td>$gg \to H$</td><td rowspan="5">di-photon p_{T} and absolute rapidity;
di-jet p_{T}, mass, Δy, $\Delta\phi$, $\Delta\eta$ between the 2 jets;
p_{T}, mass of $\gamma\gamma + j$ and $\gamma\gamma + jj$,
Δy, $\Delta\phi$ between $\gamma\gamma$ and jj,
minimum ΔR between jets and photons,
mass of the sum of all jets;
di-lepton p_{T}, di-e or di-μ mass,
E_{T}^{miss}, p_{T} of lepton + E_{T}^{miss};
p_T, η, ϕ, mass of top candidates;
Number of jets, barrel jets ($|\eta| < 2.5$), b-jets and leptons;
leading jet p_T, sum p_{T} of all jets
$\sum E^{\mathrm{T}}$, E_{T}^{miss} significance;
Average interaction per crossing, number of primary vertices</td><td rowspan="5">individual
STXS regions from
$gg \to H$ or
$qq' \to Hqq'$</td><td rowspan="5">Multi-class BDT variables, and
$\Delta\phi$, $\Delta\eta$ between the 2 photons ($\Delta\phi_{\gamma\gamma}$, $\Delta\eta_{\gamma\gamma}$);
Number of electrons and muons;
E_{T}^{miss}, $\sum E^{\mathrm{T}}$, E_{T}^{miss} significance, and
E_{T}^{miss} azimuthal angle computed from hardest vertex;
$\gamma\gamma$ $\vec{p}_{\mathrm{T}}$ projected to its thrust axis ($p_{\mathrm{Tt}}^{\gamma\gamma}$);
Half difference between di-photon η and sum η of leading 2 jets (η^{Zepp});
$\phi^*_{\gamma\gamma} = \tan(\frac{\pi - |\Delta\phi_{\gamma\gamma}|}{2})\sqrt{1 - \tanh^2(\frac{\Delta\eta_{\gamma\gamma}}{2})}$
$\cos\theta^*_{\gamma\gamma} = \lvert\frac{(E^{\gamma_1}+p_z^{\gamma_1})\cdot(E^{\gamma_2}-p_z^{\gamma_2}) - (E^{\gamma_1}-p_z^{\gamma_1})\cdot(E^{\gamma_2}+p_z^{\gamma_2})}{m_{\gamma\gamma}+\sqrt{(m_{\gamma\gamma}^2+(p_{\mathrm{T}}^{\gamma\gamma})^2)}}\rvert$</td></tr>
<tr><td>$qq' \to Hqq'$</td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td>$qq \to H\ell\nu$</td><td rowspan="2">WH
STXS regions
combined</td><td rowspan="3">$p_{\mathrm{T}}/m_{\gamma\gamma}$, η, ϕ of 2 leading photons;
p_{T}, η, ϕ of 2 leading leptons;
E_{T}^{miss}, E_{T}^{miss} significance, E_{T}^{miss} azimuthal angle;
Whether or not the E_{T}^{miss} built from di-photon vertex is
larger than that built from the hardest vertex
by more than 30 GeV;
di-lepton mass, and transverse mass of lepton + E_{T}^{miss}</td></tr>
<tr><td>$qq \to H\ell\ell$</td><td>ZH
STXS regions
combined</td></tr>
<tr><td>$t\bar{t}H$</td><td>$t\bar{t}H$
STXS regions
combined</td><td>p_{T}, η, ϕ of 2 leading photons;
p_{T}, η, ϕ and B-tagging scores of 6 leading jets;
E_{T}^{miss}, E_{T}^{miss} significance, E_{T}^{miss} azimuthal angle;
Top reconstruction BDT scores</td></tr>
<tr><td>tH</td><td>tWH, $tHqb$</td></tr>
</table>

Summary of event categories



Finally, 88 event categories in total

- S/(S+B) ranges from 3% to 83%
- Entries for the STXS regions targeted by each reconstruction category are outlined

Summary of event categories

Category	S	B	f	Z
$gg \to H$				
0-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 10\,\mathrm{GeV}$	730	24000	0.03	4.6
0-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$	2200	66000	0.03	8.4
1-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$	550	16000	0.03	4.4
1-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$	470	10000	0.04	4.7
1-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, High-purity	37	250	0.13	2.3
1-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, Med-purity	50	620	0.07	2.0
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $60 \leq p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, High-purity	39	1200	0.03	1.1
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $60 \leq p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, Med-purity	120	5300	0.02	1.6
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $60 \leq p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, Low-purity	490	19000	0.03	3.6
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $120 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, High-purity	36	370	0.09	1.8
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $120 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, Med-purity	110	2300	0.05	2.2
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $120 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, Low-purity	230	7000	0.03	2.7
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $200 \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, High-purity	44	220	0.17	2.9
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $200 \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, Med-purity	70	830	0.08	2.4
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, High-purity	4.1	17	0.19	0.9
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Med-purity	15	110	0.12	1.4
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Low-purity	16	380	0.04	0.8
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, High-purity	5.7	40	0.12	0.9
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Med-purity	20	270	0.07	1.2
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Low-purity	22	930	0.02	0.7
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, High-purity	4.4	9.0	0.33	1.4
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Med-purity	14	40	0.26	2.1
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Low-purity	16	150	0.10	1.3
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, High-purity	5.1	33	0.14	0.9
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Med-purity	14	150	0.09	1.1
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Low-purity	16	380	0.04	0.8
$200 \leq p_{\mathrm{T}}^{H} < 300\,\mathrm{GeV}$, High-purity	7.2	11	0.40	2.0
$200 \leq p_{\mathrm{T}}^{H} < 300\,\mathrm{GeV}$, Med-purity	28	84	0.25	2.9
$200 \leq p_{\mathrm{T}}^{H} < 300\,\mathrm{GeV}$, Low-purity	28	210	0.12	1.9
$300 \leq p_{\mathrm{T}}^{H} < 450\,\mathrm{GeV}$, High-purity	1.7	1.8	0.49	1.1
$300 \leq p_{\mathrm{T}}^{H} < 450\,\mathrm{GeV}$, Med-purity	7.1	10	0.41	2.0
$300 \leq p_{\mathrm{T}}^{H} < 450\,\mathrm{GeV}$, Low-purity	17	63	0.21	2.1
$450 \leq p_{\mathrm{T}}^{H} < 650\,\mathrm{GeV}$, High-purity	1.9	1.4	0.58	1.4
$450 \leq p_{\mathrm{T}}^{H} < 650\,\mathrm{GeV}$, Med-purity	2.1	7.5	0.22	0.7
$p_{\mathrm{T}}^{H} \geq 650\,\mathrm{GeV}$, High-purity	0.72	1.0	0.42	0.7
$p_{\mathrm{T}}^{H} \geq 650\,\mathrm{GeV}$, Med-purity	0.21	1.1	0.17	0.2
$qq' \to Hqq'$				
0-jet , High-purity	0.32	3.9	0.08	0.2
0-jet , Med-purity	0.60	8.1	0.07	0.2
1-jet , High-purity	1.9	2.3	0.45	1.1
1-jet , Med-purity	2.4	4.8	0.33	1.0
1-jet , Low-purity	4.9	33	0.13	0.8
$\geq$ 2-jets, $m_{jj} < 60\,\mathrm{GeV}$, High-purity	0.61	1.8	0.25	0.4
$\geq$ 2-jets, $m_{jj} < 60\,\mathrm{GeV}$, Med-purity	2.0	8.1	0.20	0.7
$\geq$ 2-jets, $m_{jj} < 60\,\mathrm{GeV}$, Low-purity	5.9	52	0.10	0.8
$\geq$ 2-jets, $60 \leq m_{jj} < 120\,\mathrm{GeV}$, High-purity	5.3	6.1	0.46	1.9
$\geq$ 2-jets, $60 \leq m_{jj} < 120\,\mathrm{GeV}$, Med-purity	6.9	32	0.18	1.2

Category	S	B	f	Z
$qq' \to Hqq'$				
$\geq$ 2-jets, $120 \leq m_{jj} < 350\,\mathrm{GeV}$, High-purity	0.91	3.0	0.23	0.5
$\geq$ 2-jets, $120 \leq m_{jj} < 350\,\mathrm{GeV}$, Med-purity	14	87	0.14	1.4
$\geq$ 2-jets, $120 \leq m_{jj} < 350\,\mathrm{GeV}$, Low-purity	27	380	0.07	1.4
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, High-purity	3.1	3.0	0.51	1.6
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Med-purity	12	51	0.19	1.6
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, High-purity	1.3	1.8	0.42	0.9
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Med-purity	0.42	4.7	0.08	0.2
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, High-purity	9.0	1.8	0.83	4.5
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Med-purity	18	22	0.45	3.5
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, High-purity	1.5	1.7	0.47	1.0
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Med-purity	2.4	3.4	0.42	1.2
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Low-purity	6.5	20	0.24	1.4
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{H} <$ GeV , High-purity	1.6	1.3	0.55	1.2
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{H} <$ GeV , Med-purity	0.55	2.0	0.22	0.4
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{H} <$ GeV , High-purity	8.1	1.6	0.83	4.3
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{H} <$ GeV , Med-purity	7.6	11	0.42	2.1
$qq \to H\ell\nu$				
Other	7.7	210	0.04	0.5
$0 \leq p_{\mathrm{T}}^{V} < 75\,\mathrm{GeV}$, High-purity	2.3	3.5	0.40	1.1
$0 \leq p_{\mathrm{T}}^{V} < 75\,\mathrm{GeV}$, Med-purity	6.3	39	0.14	1.0
$75 \leq p_{\mathrm{T}}^{V} < 150\,\mathrm{GeV}$, High-purity	3.7	1.8	0.67	2.2
$75 \leq p_{\mathrm{T}}^{V} < 150\,\mathrm{GeV}$, Med-purity	1.3	4.8	0.21	0.6
$150 \leq p_{\mathrm{T}}^{V} < 250\,\mathrm{GeV}$, 0-jet	1.8	1.9	0.48	1.1
$150 \leq p_{\mathrm{T}}^{V} < 250\,\mathrm{GeV}$, 1-jet	2.2	2.3	0.49	1.3
$p_{\mathrm{T}}^{V} \geq 250\,\mathrm{GeV}$	1.5	1.2	0.56	1.2
$qq \to H\ell\ell$				
Other	11	280	0.04	0.6
$0 \leq p_{\mathrm{T}}^{V} < 75\,\mathrm{GeV}$	0.9	1.8	0.32	0.6
$75 \leq p_{\mathrm{T}}^{V} < 150\,\mathrm{GeV}$, High-purity	3.2	3.9	0.45	1.4
$75 \leq p_{\mathrm{T}}^{V} < 150\,\mathrm{GeV}$, Med-purity	5.6	21	0.21	1.2
$150 \leq p_{\mathrm{T}}^{V} < 250\,\mathrm{GeV}$, 0-jet	1.6	2.1	0.42	1.0
$150 \leq p_{\mathrm{T}}^{V} < 250\,\mathrm{GeV}$, 1-jet	1.7	3.2	0.35	0.9
$p_{\mathrm{T}}^{V} \geq 250\,\mathrm{GeV}$	1.8	2.0	0.47	1.1
$t\bar{t}H$				
Other (including tH)	11	120	0.08	1.0
$p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, High-purity	3.2	5.0	0.39	1.3
$p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, Med-purity	3.5	15	0.18	0.8
$60 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, High-purity	5.1	4.3	0.54	2.1
$60 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, Med-purity	3.7	10	0.26	1.1
$120 \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, High-purity	6.1	3.8	0.62	2.6
$120 \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, Med-purity	3.1	8.1	0.28	1.0
$200 \leq p_{\mathrm{T}}^{H} < 300\,\mathrm{GeV}$	4.6	1.7	0.73	2.7
$p_{\mathrm{T}}^{H} \geq 300\,\mathrm{GeV}$	3.6	1.0	0.78	2.6
tHW	0.80	2.4	0.25	0.5
$tHqb$	0.88	2.7	0.24	0.5

Summary of event categories

Category	σ_{68} (GeV)	Function
$gg \to H$		
0-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 10\,\mathrm{GeV}$	1.95	ExpPoly2
0-jet, $p_{\mathrm{T}}^{H} \geq p_{\mathrm{T}}^{H}$ GeV	1.94	ExpPoly2
1-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$	1.89	ExpPoly2
1-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$	1.84	ExpPoly2
1-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, High-purity	1.50	ExpPoly2
1-jet, $p_{\mathrm{T}}^{H} \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, Med-purity	1.73	PowerLaw
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $60 \leq p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, High-purity	1.76	ExpPoly2
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $60 \leq p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, Med-purity	1.91	ExpPoly2
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $60 \leq p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, Low-purity	1.99	ExpPoly2
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $120 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, High-purity	1.65	ExpPoly2
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $120 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, Med-purity	1.80	ExpPoly2
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $120 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, Low-purity	1.87	Exp
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $200 \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, High-purity	1.52	ExpPoly2
$\geq$ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $200 \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, Med-purity	1.66	PowerLaw
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, High-purity	1.62	PowerLaw
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Med-purity	1.74	Exp
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Low-purity	1.93	Exp
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, High-purity	1.50	Exp
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Med-purity	1.68	ExpPoly2
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Low-purity	1.82	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, High-purity	1.67	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Med-purity	1.79	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Low-purity	1.95	PowerLaw
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, High-purity	1.63	PowerLaw
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Med-purity	1.77	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Low-purity	1.89	PowerLaw
$200 \leq p_{\mathrm{T}}^{H} < 300\,\mathrm{GeV}$, High-purity	1.27	Exp
$200 \leq p_{\mathrm{T}}^{H} < 300\,\mathrm{GeV}$, Med-purity	1.35	Exp
$200 \leq p_{\mathrm{T}}^{H} < 300\,\mathrm{GeV}$, Low-purity	1.52	PowerLaw
$300 \leq p_{\mathrm{T}}^{H} < 450\,\mathrm{GeV}$, High-purity	1.09	Exp
$300 \leq p_{\mathrm{T}}^{H} < 450\,\mathrm{GeV}$, Med-purity	1.18	PowerLaw
$300 \leq p_{\mathrm{T}}^{H} < 450\,\mathrm{GeV}$, Low-purity	1.33	PowerLaw
$450 \leq p_{\mathrm{T}}^{H} < 650\,\mathrm{GeV}$, High-purity	1.07	Exp
$450 \leq p_{\mathrm{T}}^{H} < 650\,\mathrm{GeV}$, Med-purity	1.12	Exp
$p_{\mathrm{T}}^{H} \geq 650\,\mathrm{GeV}$, High-purity	1.00	Exp
$p_{\mathrm{T}}^{H} \geq 650\,\mathrm{GeV}$, Med-purity	1.09	Exp
$qq' \to Hqq'$		
0-jet , High-purity	1.70	Exp
0-jet , Med-purity	1.91	Exp
1-jet , High-purity	1.65	Exp
1-jet , Med-purity	1.68	Exp
1-jet , Low-purity	1.84	PowerLaw
$\geq$ 2-jets, $m_{jj} < 60\,\mathrm{GeV}$, High-purity	1.62	Exp
$\geq$ 2-jets, $m_{jj} < 60\,\mathrm{GeV}$, Med-purity	1.59	Exp
$\geq$ 2-jets, $m_{jj} < 60\,\mathrm{GeV}$, Low-purity	1.62	Exp
$\geq$ 2-jets, $60 \leq m_{jj} < 120\,\mathrm{GeV}$, High-purity	1.49	Exp
$\geq$ 2-jets, $60 \leq m_{jj} < 120\,\mathrm{GeV}$, Med-purity	1.55	PowerLaw

Category	σ_{68} (GeV)	Function
$qq' \to Hqq'$		
$\geq$ 2-jets, $120 \leq m_{jj} < 350\,\mathrm{GeV}$, High-purity	1.69	Exp
$\geq$ 2-jets, $120 \leq m_{jj} < 350\,\mathrm{GeV}$, Med-purity	1.67	Exp
$\geq$ 2-jets, $120 \leq m_{jj} < 350\,\mathrm{GeV}$, Low-purity	1.67	PowerLaw
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, High-purity	1.65	Exp
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Med-purity	1.77	Exp
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, High-purity	1.69	Exp
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Med-purity	1.88	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, High-purity	1.65	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} < 25\,\mathrm{GeV}$, Med-purity	1.81	PowerLaw
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, High-purity	1.65	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Med-purity	1.63	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{Hjj} \geq 25\,\mathrm{GeV}$, Low-purity	1.76	Exp
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{H} <$ GeV , High-purity	1.38	Exp
$\geq$ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{H} <$ GeV , Med-purity	1.49	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{H} <$ GeV , High-purity	1.38	Exp
$\geq$ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $p_{\mathrm{T}}^{H} <$ GeV , Med-purity	1.44	Exp
$qq \to H\ell\nu$		
Other	1.88	Exp
$0 \leq p_{\mathrm{T}}^{V} < 75\,\mathrm{GeV}$, High-purity	1.64	Exp
$0 \leq p_{\mathrm{T}}^{V} < 75\,\mathrm{GeV}$, Med-purity	1.87	Exp
$75 \leq p_{\mathrm{T}}^{V} < 150\,\mathrm{GeV}$, High-purity	1.64	Exp
$75 \leq p_{\mathrm{T}}^{V} < 150\,\mathrm{GeV}$, Med-purity	1.87	Exp
$150 \leq p_{\mathrm{T}}^{V} < 250\,\mathrm{GeV}$, 0-jet	1.60	Exp
$150 \leq p_{\mathrm{T}}^{V} < 250\,\mathrm{GeV}$, 1-jet	1.52	Exp
$p_{\mathrm{T}}^{V} \geq 250\,\mathrm{GeV}$	1.35	Exp
$qq \to H\ell\ell$		
Other	2.15	Exp
$0 \leq p_{\mathrm{T}}^{V} < 75\,\mathrm{GeV}$	1.85	Exp
$75 \leq p_{\mathrm{T}}^{V} < 150\,\mathrm{GeV}$, High-purity	1.73	Exp
$75 \leq p_{\mathrm{T}}^{V} < 150\,\mathrm{GeV}$, Med-purity	1.78	Exp
$150 \leq p_{\mathrm{T}}^{V} < 250\,\mathrm{GeV}$, 0-jet	1.60	Exp
$150 \leq p_{\mathrm{T}}^{V} < 250\,\mathrm{GeV}$, 1-jet	1.58	Exp
$p_{\mathrm{T}}^{V} \geq 250\,\mathrm{GeV}$	1.36	Exp
$t\bar{t}H$		
Other (including tH)	1.74	Exp
$p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, High-purity	1.81	Exp
$p_{\mathrm{T}}^{H} < 60\,\mathrm{GeV}$, Med-purity	1.90	Exp
$60 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, High-purity	1.72	Exp
$60 \leq p_{\mathrm{T}}^{H} < 120\,\mathrm{GeV}$, Med-purity	1.86	Exp
$120 \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, High-purity	1.54	Exp
$120 \leq p_{\mathrm{T}}^{H} < 200\,\mathrm{GeV}$, Med-purity	1.66	Exp
$p_{\mathrm{T}}^{H} \geq 200\,\mathrm{GeV}$	1.37	Exp
$p_{\mathrm{T}}^{H} \geq 300\,\mathrm{GeV}$	1.17	Exp
tHW	1.59	Exp
$tHqb$	1.63	Exp

Production mode cross sections

Process ($\lvert y_H\rvert < 2.5$)	Value [fb]	Uncertainty [fb] Total	Stat.	Syst.	SM pred. [fb]
ggF + $b\bar{b}H$	104	$^{+11}_{-11}$	$^{+8}_{-8}$	$^{+7}_{-6}$	102 ± 5
VBF	10.7	$^{+2.1}_{-1.9}$	± 1.4	$^{+1.4}_{-1.3}$	8.0 ± 0.2
WH	6.4	$^{+1.5}_{-1.4}$	$^{+1.5}_{-1.3}$	$^{+0.4}_{-0.3}$	2.7 ± 0.1
ZH	-1.2	$^{+1.1}_{-1.0}$	$^{+1.1}_{-1.0}$	± 0.1	$1.8\ ^{+0.1}_{-0.1}$
$t\bar{t}H$+ tH	1.2	$^{+0.4}_{-0.3}$	± 0.3	± 0.1	1.3 ± 0.1

Simplified template cross sections

STXS region ($\sigma_i \times B_{\gamma\gamma}$)	Value [fb]	Uncertainty [fb] Total	Stat.	Syst.	SM prediction [fb]
$gg \to H$ (0-jet, $p_{\mathrm{T}}^H \leq p_{\mathrm{T}}^H < 10\,\mathrm{GeV}$)	11.4	$^{+4.7}_{-4.5}$	$^{+3.9}_{-3.9}$	$^{+2.7}_{-2.4}$	15.0 ± 2.0
$gg \to H$ (0-jet, $p_{\mathrm{T}}^H \leq p_{\mathrm{T}}^H < 200\,\mathrm{GeV}$)	54.7	$^{+9.4}_{-8.9}$	$^{+7.0}_{-7.0}$	$^{+6.1}_{-5.2}$	$46.8^{+3.5}_{-3.6}$
$gg \to H$ (1-jet, $p_{\mathrm{T}}^H \leq p_{\mathrm{T}}^H < 60\,\mathrm{GeV}$)	13.4	$^{+6.5}_{-6.3}$	$^{+5.9}_{-5.9}$	$^{+2.8}_{-2.4}$	14.7 ± 2.1
$gg \to H$ (1-jet, $p_{\mathrm{T}}^H \leq p_{\mathrm{T}}^H < 120\,\mathrm{GeV}$)	12.1	$^{+4.0}_{-3.8}$	$^{+3.8}_{-3.8}$	$^{+1.5}_{-0.6}$	10.2 ± 1.5
$gg \to H$ (1-jet, $p_{\mathrm{T}}^H \leq p_{\mathrm{T}}^H < 200\,\mathrm{GeV}$)	1.2	$^{+0.9}_{-0.9}$	$^{+0.9}_{-0.9}$	$^{+0.2}_{-0.2}$	1.7 ± 0.3
$gg \to H$ (≥ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $60 \leq p_{\mathrm{T}}^H < 60\,\mathrm{GeV}$)	1.2	$^{+3.4}_{-3.2}$	$^{+3.1}_{-3.0}$	$^{+1.5}_{-1.0}$	2.6 ± 0.6
$gg \to H$ (≥ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $120 \leq p_{\mathrm{T}}^H < 120\,\mathrm{GeV}$)	1.1	$^{+2.4}_{-2.4}$	$^{+2.3}_{-2.3}$	$^{+0.5}_{-0.5}$	4.1 ± 0.9
$gg \to H$ (≥ 2-jets, $m_{jj} < 350\,\mathrm{GeV}$, $200 \leq p_{\mathrm{T}}^H < 200\,\mathrm{GeV}$)	1.3	$^{+1.0}_{-1.0}$	$^{+0.9}_{-0.9}$	$^{+0.4}_{-0.3}$	2.1 ± 0.6
$gg \to H$ (≥ 2-jets, $m_{jj} \geq 350\,\mathrm{GeV}$, $200 \leq p_{\mathrm{T}}^H < 200\,\mathrm{GeV}$)	4.5	$^{+2.0}_{-1.8}$	$^{+1.8}_{-1.7}$	$^{+0.9}_{-0.6}$	2.0 ± 0.25
$gg \to H$ ($200 \leq p_{\mathrm{T}}^H < 300\,\mathrm{GeV}$)	1.0	$^{+0.4}_{-0.4}$	$^{+0.4}_{-0.4}$	$^{+0.1}_{-0.1}$	1.04 ± 0.3
$gg \to H$ ($300 \leq p_{\mathrm{T}}^H < 450\,\mathrm{GeV}$)	0.05	$^{+0.14}_{-0.12}$	$^{+0.13}_{-0.12}$	$^{+0.03}_{-0.02}$	0.24 ± 0.08
$gg \to H$ ($p_{\mathrm{T}}^H \geq 450\,\mathrm{GeV}$)	0.07	$^{+0.06}_{-0.05}$	$^{+0.06}_{-0.05}$	$^{+0.01}_{-0.00}$	0.04 ± 0.02
$qq' \to Hqq'$ (≤ 1-jet)	7.4	$^{+5.9}_{-5.2}$	$^{+5.5}_{-4.9}$	$^{+2.1}_{-1.8}$	$4.8^{+0.1}_{-0.1}$
$qq' \to Hqq'$ (≥ 2-jets, $0 \leq m_{jj} < 60\,\mathrm{GeV}$) + $qq' \to Hqq'$ (≥ 2-jets, $120 \leq m_{jj} < 350\,\mathrm{GeV}$)	5.2	$^{+3.0}_{-2.8}$	$^{+2.8}_{-2.7}$	$^{+1.2}_{-0.9}$	1.65 ± 0.05
$qq' \to Hqq'$ (≥ 2-jets, $60 \leq m_{jj} < 120\,\mathrm{GeV}$)	0.9	$^{+1.1}_{-1.0}$	$^{+1.1}_{-1.0}$	$^{+0.3}_{-0.3}$	1.20 ± 0.04
$qq' \to Hqq'$ (≥ 2-jets, $350 \leq m_{jj} < 700\,\mathrm{GeV}$, $200 \leq p_{\mathrm{T}}^H < 200\,\mathrm{GeV}$)	1.0	$^{+0.9}_{-0.8}$	$^{+0.8}_{-0.7}$	$^{+0.5}_{-0.4}$	1.24 ± 0.04
$qq' \to Hqq'$ (≥ 2-jets, $m_{jj} \geq 700\,\mathrm{GeV}$, $200 \leq p_{\mathrm{T}}^H < 200\,\mathrm{GeV}$)	1.8	$^{+0.6}_{-0.5}$	$^{+0.5}_{-0.4}$	$^{+0.4}_{-0.3}$	1.67 ± 0.05
$qq' \to Hqq'$ (≥ 2-jets, $m_{jj} \geq 350\,\mathrm{GeV}$, $p_{\mathrm{T}}^H <$ GeV)	0.5	$^{+0.2}_{-0.2}$	$^{+0.2}_{-0.1}$	$^{+0.07}_{-0.06}$	0.36 ± 0.01
$qq \to H\ell\nu$ ($p_{\mathrm{T}}^V < 150\,\mathrm{GeV}$)	1.8	$^{+0.5}_{-0.5}$	$^{+0.5}_{-0.5}$	$^{+0.2}_{-0.2}$	0.76 ± 0.02
$qq \to H\ell\nu$ ($p_{\mathrm{T}}^V \geq 150\,\mathrm{GeV}$)	0.3	$^{+0.1}_{-0.1}$	$^{+0.1}_{-0.1}$	$^{+0.02}_{-0.02}$	0.124 ± 0.005
$qq \to H\ell\ell$ ($p_{\mathrm{T}}^V < 150\,\mathrm{GeV}$)	-0.5	$^{+0.4}_{-0.4}$	$^{+0.4}_{-0.4}$	$^{+0.1}_{-0.1}$	0.45 ± 0.02
$qq \to H\ell\ell$ ($p_{\mathrm{T}}^V \geq 150\,\mathrm{GeV}$)	-0.01	$^{+0.10}_{-0.09}$	$^{+0.10}_{-0.08}$	$^{+0.01}_{-0.02}$	0.092 ± 0.011
$t\bar{t}H$ ($p_{\mathrm{T}}^H < 60\,\mathrm{GeV}$)	0.2	$^{+0.2}_{-0.2}$	$^{+0.2}_{-0.2}$	$^{+0.06}_{-0.05}$	0.27 ± 0.04
$t\bar{t}H$ ($60 \leq p_{\mathrm{T}}^H < 120\,\mathrm{GeV}$)	0.3	$^{+0.2}_{-0.2}$	$^{+0.2}_{-0.2}$	$^{+0.04}_{-0.03}$	$0.40^{+0.05}_{-0.04}$
$t\bar{t}H$ ($120 \leq p_{\mathrm{T}}^H < 200\,\mathrm{GeV}$)	0.3	$^{+0.2}_{-0.2}$	$^{+0.2}_{-0.2}$	$^{+0.05}_{-0.04}$	0.29 ± 0.03
$t\bar{t}H$ ($p_{\mathrm{T}}^H \geq 200\,\mathrm{GeV}$)	0.2	$^{+0.09}_{-0.08}$	$^{+0.09}_{-0.08}$	$^{+0.02}_{-0.02}$	0.18 ± 0.02
tH	0.2	$^{+0.6}_{-0.5}$	$^{+0.6}_{-0.4}$	$^{+0.2}_{-0.2}$	$0.19^{+0.01}_{-0.02}$